Risk Assessment Mitigation Phase
Risk Mitigation Plan
Climate Change Adaptation
(Chapter SCG-9)

November 30, 2016

310273

SoCalGas
A Sempra Energy utility

TABLE OF CONTENTS

Executive Summary

The purpose of this chapter is to present the mitigation plan of the Southern California Gas Company (SoCalGas) for the risk of Climate Change Adaptation. The Climate Change Adaptation risk involves safety-related threats to gas infrastructure posed by global climate change, and addressing this risk through formal planning and adaptive actions. SoCalGas' 2015 baseline mitigation plan for this risk consists of the following controls:

- For 2015, SoCalGas' research partnership with the Pipeline Research Council International (PRCI) developed the geological hazard engineering program, including satellite monitoring. The geological hazard engineering program included research related to increase extreme weather events and subsidence. Also included are efforts to stabilize land movement and/or erosive forces at Storage facilities that were identified in the program.

These controls focus on safety-related impacts (i.e., Health, Safety, and Environment) per guidance provided by the Commission in Decision 16-08-018 as well as controls and mitigations that may address reliability. SoCalGas' proposed mitigation plan comprises both baseline and new mitigation activities.

Based on the foregoing assessment, SoCalGas proposed future mitigations. For Climate Change Adaptation, SoCalGas proposed to continue the controls, identified above, but included enhancements. The enhancements include:

1. Gas Infrastructure Resilience & Vulnerability Report
2. Geological Hazard Engineering Data Analysis and Flood Hazard Dashboard
3. Strain Gauge Installation Projects
4. Slope Stability & Erosion Control Projects

A risk spend efficiency analysis was not performed for the Climate Change Adaptation risk because there is no linkage to adaptive or corrective actions which would have any measurable effect on the probability of their predicted safety consequences.

Finally, SoCalGas considered two alternatives to the proposed mitigations, and in the final section of this chapter, SoCalGas explains the reasons those alternatives were not included into its proposal.

Risk: Climate Change Adaptation

1 Purpose

The purpose of this chapter is to present the adaptation assessment and mitigation plan of Southern California Gas Company (SoCalGas or Company) for the safety-related threats to gas infrastructure posed by global climate change.[1] The Intergovernmental Panel on Climate Change (IPCC) defines *Adaptation Assessment* as the practice of identifying options to adapt to climate change.[2] In addition, the IPCC also defines *Adaptation* as the adjustment in natural or human systems in response to actual or expected climatic changes.[3] This is different from *Mitigation*, which refers to human interventions to reduce anthropogenic forcing, including implementing processes to reduce greenhouse gas emissions.[4]

SoCalGas and San Diego Gas & Electric Company (SDG&E)(collectively, the utilities) take compliance and managing risks seriously, as can be seen by the amount of actions taken to mitigate each risk. This is the first time, however, that the utilities have presented a Risk Assessment Mitigation Phase (RAMP) Report, so it is important to consider the data presented in this plan in that context. The baseline mitigations are determined based on the relative expenditures during 2015; however, the utilities do not currently track expenditures in this way, so the baseline amounts are the best effort of the utility to benchmark both capital and operations and maintenance (O&M) costs during that year. The level of precision in process and outcomes is expected to evolve through work with the California Public Utilities Commission (Commission or CPUC) and other stakeholders over the next several General Rate Case (GRC) cycles.

The Commission has ordered that RAMP be focused on safety related risks and mitigating those risks.[5] In many risks, safety and reliability are inherently related and cannot be separated, and the mitigations reflect that fact. Compliance with laws and regulations is also inherently tied to safety and the utilities take those activities very seriously. In all cases, the 2015 baseline mitigations include activities and amounts necessary to comply with the laws in place at that time. Laws rapidly evolve, however, so the RAMP baseline has not taken into account any new laws that have been passed since September 2015. Some proposed mitigations, however, do take into account those new laws.

---

[1] Impact of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 2, *available at* http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task3/task_3.1/page06.cfm.

[2] https://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html.

[3] *See* https://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html. Climate Change Adaptation – Adjustments to infrastructure and installation of monitoring systems in potential vulnerable infrastructure due to the threats posed by climate change. Climate Change Mitigation – Replacing Diesel operated fleet with natural gas operated fleet to reduce emissions.

[4] https://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-e-o.html.

[5] Commission Decision (D.) 14-12-025 at p. 31.

Climate change is an emerging issue projected to expand over the coming decades in the form of climate threats. As the impacts of climate change are likely to become more severe, and current climate shifts may become more long term, both public and private entities are developing adaptation plans to insulate their operations. This is particularly salient with energy resource infrastructure. For example, just in the last few years there has been an increased awareness of the impacts of severe weather events on the vulnerability of energy, communication and transportation infrastructure mainly caused by massive electric outages from these climate-driven events (severe storms, wind-storms, etc.). However, the gas system is one area of the energy infrastructure that tends to be resilient to these severe above ground threats due to its network being mostly underground.[6] As each community can be affected differently from climate change, formal planning and adaptive actions are needed to address these changes on a proactive basis. This can be done in the format of a climate adaptation plan. SoCalGas is adapting to this reality by completing a vulnerability assessment and identifying the following five threats that may have a broad reach across many departments and linkage to the mitigation plans presented in other RAMP risk chapters.

Identified Threats:

1. Increased frequency and severity of storm events
2. Sea level rise
3. Change in precipitation patterns and drought
4. Change in temperature extremes
5. Increased wildfire frequency and intensity

To address the risk of Climate Change Adaptation, SoCalGas focused on the drivers of climate change and the potential resulting impacts, which in turn yielded the adaptation assessment and mitigation efforts presented in this chapter. This chapter establishes the mitigation efforts that SoCalGas implemented in 2015 and the proposed subsequent efforts through 2019. In addition, this risk chapter will also address the connection and collaboration between the Climate Change Adaptation risk and other risk chapters in the RAMP, which describe mitigation efforts related to the safety of employees, the public, and the gas infrastructure. These other RAMP chapters are *Catastrophic Damage Involving High-Pressure Gas Pipeline Failure, Catastrophic Damage Involving Medium-Pressure Gas Pipeline*

[6] With a more protected and resilient underground system, natural gas can become a source of energy for many consumers when electricity infrastructure is interrupted. For example, one can use natural gas to generate electricity locally using distributed generation from fuel cells, micro-turbines and/or combined heat and power system. Also, vehicles and associated fueling infrastructure not wholly dependent on electricity either directly or indirectly can be more resilient to climate change threats. A fleet and fueling infrastructure where a company uses renewable natural gas or hydrogen to fuel their alternative fueled vehicles can further support mitigating the impacts of climate change by decarbonizing or reducing the carbon intensity of vehicle fuel while supporting long term resilience to climate change.

Failure, and the risk of *Employee, Contractor, Customer and Public Safety*. Please refer to these RAMP chapters for additional information about their specific risk mitigation plans.

Furthermore, climate risks are realized over long-term periods, and SoCalGas intends to continue its expansion of knowledge. It is not the role of SoCalGas to question the validity of climate change, but rather to interpret physical data and results of climate studies to responsibly determine the potential effect of said data on SoCalGas assets. Additionally, SoCalGas' current, not future, mitigation efforts to reduce its greenhouse gas emissions were not included in this RAMP chapter because this chapter is presenting the adaptation assessment and mitigation efforts for climate change adaptation, and not for climate change mitigation, as discussed above.

2 Background

SoCalGas conducted a literature review of sources, including federal and local studies. These sources include: (1) Impact of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study Phase 2, (2) Measuring Disaster Resilience: The Impact of Hurricane Sandy on Critical Infrastructure Systems, (3) Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure, (4) the SDG&E Vulnerability Report and (5) the SoCalGas San Joaquin Valley Piping System Ground Deformation Geological Engineering study.[7] In 2015, SoCalGas identified potential regional risks due to climate change to its gas infrastructure, primarily the transmission pipelines. The transmission pipelines, which operate at a high pressure, were the initial target for assessment in 2015 because a failure or rupture due to a climate change-related risk may potentially result in a catastrophic event compared to a failure on medium-pressure pipelines.

The initial assessments led SoCalGas to focus on transmission pipelines in three major areas of the SoCalGas territory: the San Joaquin Valley, selected for its history of drought and subsidence, the Cajon Pass corridor, selected due to its history of landslides, and the Coastal Valley, also selected based on its history of landslides and mudslides. This information was reviewed by subject matter experts within the Company to verify, validate, and determine additional adaptation assessments needed. Within these

[7] "Impact of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 2," *available at* http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task3/task_3.1/page06.cfm; "Measuring Disaster Resilience: The Impact of Hurricane Sandy on Critical Infrastructure Systems," Paper by Tina Comes and Bartel Van de Walle, *available at* http://www.iscramlive.org/ISCRAM2014/papers/p18.pdf; "Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure," Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy, *available at* http://energy.gov/sites/prod/files/2013/04/f0/Northeast%20Storm%20Comparison_FINAL_041513b.pdf; "SDG&E Vulnerability Report," Department of Energy Partnership for Energy Sector Climate Resilience; "SoCalGas San Joaquin Valley Piping System Ground Deformation Geological Engineering Study," SoCalGas Geological Hazard Engineering Program.

three major areas, SoCalGas initiated projects to monitor land movement and respond to El Niño events, specifically landslides or mudslides.

3 Risk Information

As stated in the testimony of Jorge M. DaSilva in the Safety Model Assessment Proceeding (S-MAP) Applications (A.) 15-05-004, "SoCalGas is moving towards a more structured approach to classifying risks and mitigations through the development of its new risk taxonomy. The purpose of the risk taxonomy is to define a rational, logical and common framework that can be used to understand analyze and categorize risks."[8] The Enterprise Risk Management (ERM) process and lexicon that the Companies have put in place were built on the internationally-accepted IS0 31000 risk management standard. In the application and evolution of this process, the Companies are committed to increasing the use of quantification within its evaluation and prioritization of risks.[9] This includes identifying leading indicators of risk. Sections 2 – 9 of this plan describe the key outputs of the ERM process and resultant risk mitigations.

In accordance with the ERM process, this section describes the risk classification, possible drivers and potential consequences of the Climate Change Adaptation risk.

3.1 Risk Classification

Consistent with the taxonomy presented by the Companies in A.15-05-004, SoCalGas classifies this risk this as a cross-cutting risk that affects both people and business function that stems from changes in global climate patterns not consistent with long-standing historical trends. The risk classification is provided in Table 1 below.

Table 1: Risk Classification per Taxonomy

Risk Type	Asset/Function Category	Asset/Function Type
Cross-cutting	People/Underground/Above-ground Facilities	Global temperature rise/Rainfall patterns

3.2 Potential Drivers[10]

When performing the risk adaptation assessment for Climate Change Adaptation, SoCalGas' subject matter experts (SMEs) assessed literature sources and locations to identify the potential leading indicators or factors of climate change, referred to as drivers. These high level climate change drivers were essential to identifying the five threats summarized in the Purpose section. By understanding these drivers, the five identified threats and their consequences, SoCalGas can then assess the potential impact to safety of the public, customers, contractors, and employees and the safety and reliability of the gas

[8] A.15-05-002/004, filed May 1, 2015, at p. JMD-7.
[9] Testimony of Diana Day, Risk Management and Policy (SDG&E-02), submitted on November 14, 2014 in A.14-11-003.
[10] An indication that a risk could occur. It does not reflect actual or threatened conditions.

infrastructure. The potential consequences are described in Section 3.3. It is important to note that climate change in itself is a driver to the realization of events discussed in other RAMP chapters as discussed above, such as a mudslide or landslide that results in pipeline failures. Nonetheless, potential drivers of climate change are listed below as the focus of this chapter, which in turn can result in the five threats.

Potential Drivers

- Increase in global temperatures[11]
- Storm Surge[12]

Identified Threats:

- Increased frequency and severity of storm events
  - Increased extreme weather events including, but not limited to, wind storms and heavy rainfall (El Niño events)
- Sea level rise
  - Coastal flooding due to sea level rise
- Change in precipitation patterns and drought
  - Subsidence due to drought/groundwater depletion
  - Effectiveness of Cathodic Protection systems diminish with drier soils
  - Landslides and mudslides due to drought induced vegetation loss in conjunction with changing rainfall patterns.
    - Reduce access to pipeline Right of Ways (ROWs)
- Change in temperature extremes
  - Increased electric generation and demand from natural gas
- Increased wildfire frequency and intensity
  - Weakened soil structure and erosion, which can expose underground pipelines

3.3 Potential Consequences

The natural gas system tends to be resilient to climate change threats because it is mostly underground and most impacts are above ground. If one looks at recent incidents, such as Hurricane Sandy affecting areas with gas infrastructure, those natural gas systems remained essentially intact and were resilient and

[11] Impact of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 2: http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task3/task_3.1/page06.cfm.

[12] Impact of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coat Study, Phase 2: http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task3/task_3.1/page06.cfm.

reliable in these above ground weather-related events.[13] Nationally, unlike the electric system that will have more regional wide impacts from above ground driven climate change events, natural gas systems tend to be impacted in isolated or distinct segments.

Table 2 below summarizes the key threats, events, and potential consequences that can occur as a result of climate change. These potential consequences, in a reasonable worst case scenario, could impact gas system planning and design, operation and maintenance, and emergency response in multiple departments in SoCalGas.

Table 2: Threat, Events, and Potential Consequences

Threat	Events	Potential Consequences
Increased Frequency and Severity of Storm Events	Storm Surge (El Niño events), Flooding, high winds, and heavy snow.	1. Increased frequency of emergency response from Gas Emergency Centers (GECs) and SoCalGas crews. 2. Levee erosion or failure causing asset repair, replacement or relocation to low-lying above and below ground gas assets. 3. Exposure of underground pipelines.
Change in Precipitation Patterns and Droughts	Subsidence, Landslides, Mudslides, weakened soil structure, drought induced vegetation loss.	1. Horizontal subsidence cause compressive stresses resulting in buckling of gas pipelines.[14] 2. Exposure of underground pipelines. 3. Reduce access to pipeline Right of Ways. 4. Effectiveness of cathodic protection system diminishes which can lead to increased corrosion. 5. Damage on pipelines in bridges or spans due to mudslides.
Sea Level Rise	Erosion, coastal inundation and flooding potential.	1. Levee erosion or failure causing asset repair, replacement or relocation to low-lying above and below ground gas assets. 2. Exposure of underground pipelines.

[13] "Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure," Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy, *available at* http://energy.gov/sites/prod/files/2013/04/f0/Northeast%20Storm%20Comparison_FINAL_041513b.pdf.

[14] SoCalGas is not aware of research indicating that the climate change threats noted would result in horizontal subsidence; however, oil extraction and water extraction can potentially cause subsidence.

Change in Temperature Extremes	Increase natural gas demand for electric generation for meeting more cooling days or air conditioning (HVAC) demand. Increased ambient temperatures.	1. Increased cycling of compressor station and maintenance schedules along with design requirements for Compressor Stations to support the increased cycling. 2. Damage on pipelines in bridges or spans due to thermal expansion.
Increase Wildfire Frequency and Intensity	Wildfires, vegetation loss, weakened soil structure, and landslides.	1. Increased frequency of emergency response from GECs and SoCalGas crews including standby to prevent damages to infrastructure by third parties responding to the fires. 2. Increased customer outages. 3. Increased risk of erosion and landslides due to vegetation loss.

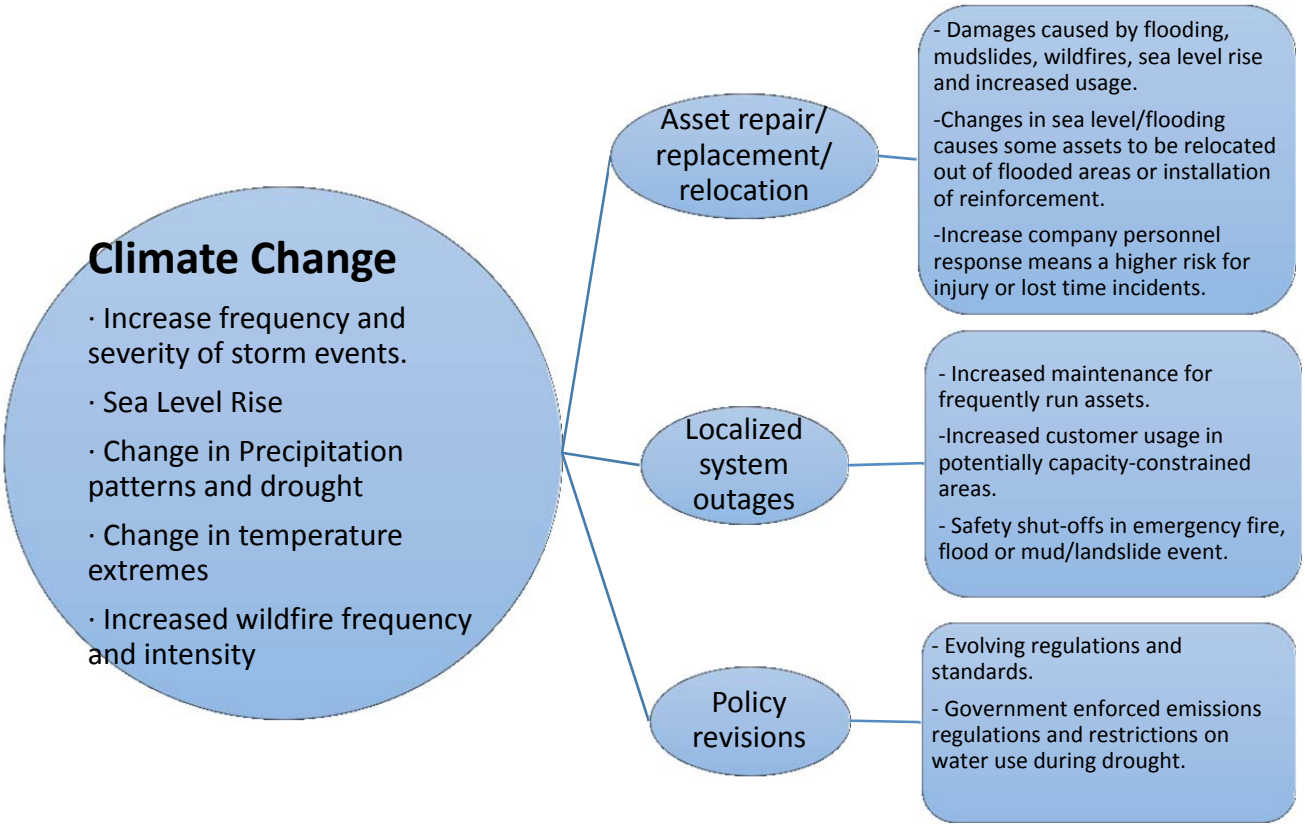
These potential consequences were used in the scoring of the Climate Change Adaptation risk that occurred during the Companies' 2015 risk registry process. See Section 4 for more detail.

3.4 Risk Chart[15]

Figure 1 shown below is to pictorially depict the risk of Climate Change Adaptation. The large dot to the left illustrates the drivers that lead to a risk event, and the right side shows the potential consequences of a risk event. SoCalGas developed this risk chart for the Climate Change Adaptation risk to summarize all the information provided above.

[15] Climate change is a potential driver that can lead to a risk event. For example, a pipeline rupture (risk event) could occur because climate change may affect cathodic protection. Unlike other risks identified in this RAMP Report represented in the traditional bow tie diagram as the risk event, climate change as a driver did not suit that representation.

Figure 1: Risk Chart



4 Risk Score

The Companies' ERM organization facilitated the 2015 risk registry process, which resulted in the inclusion of Climate Change Adaptation risk as one of the enterprise risks. During the development of the risk registry, SMEs assigned a score to this risk,[16] based on empirical data to the extent it is available and/or using their expertise, following the process outlined in this section.

4.1 Risk Scenario – Reasonable Worst Case

There are many possible ways in which a Climate Change Adaptation threat can occur. For purposes of scoring this risk, subject matter experts used a reasonable worst case scenario to assess the impact and

[16] SoCalGas Risk Score was adopted from the risk assessment conducted by SDG&E.

frequency. The scenario represented a situation that could happen, within a reasonable timeframe, and lead to a relatively significant adverse outcome. These types of scenarios are sometimes referred to as low frequency, high consequence events. The subject matter experts selected a reasonable worst case scenario to develop a risk score for Climate Change Adaptation:

- An extreme rain event known as El Niño has hit the SoCalGas territory after several years of drought resulting in high risk areas giving way to land/mudslides and flooding in low-lying areas. There are damages to access roads and multiple exposures of high pressure pipelines along with one of the pipelines failing. Multiple-year projects are required involving extensive permitting and repairs to restore the infrastructure with millions of dollars in costs.

Note that the following narrative and scores are based on this scenario; they do not address all consequences that can happen.

4.2 2015 Risk Assessment

Using this scenario, subject matter experts then evaluated the frequency of occurrence and potential impact of the risk using the Companies' 7X7 Risk Evaluation Framework (REF). The framework (also called a matrix) includes criteria to assess levels of impact ranging from Insignificant to Catastrophic and levels of frequency ranging from Remote to Common. The 7X7 framework includes one or more criteria to distinguish one level from another. The Commission adopted the REF as a valid method to assess risks for purposes of this RAMP.[17] Using the levels defined in the REF, the subject matter experts applied empirical data to the extent it is available and/or their expertise to determine a score for each of four residual impact areas and the frequency of occurrence of the risk.

Table 3 provides a summary of the Climate Change Adaptation risk score in 2015. This risk has a score of 4 or above in the Health, Safety, and Environmental impact area and, therefore, was included in the RAMP. These are residual scores because they reflect the risk remaining after existing controls are in place. For additional information regarding the REF, please refer to the RAMP Risk Management Framework chapter within this Report.

[17] D.16-08-018 Ordering Paragraph 9.

Table 3: Risk Score

Residual Impact				Residual Frequency	Residual Risk Score
Health, Safety, Environmental (40%)	Operational & Reliability (20%)	Regulatory, Legal, Compliance (20%)	Financial (20%)		
4	5	4	5	3	2,656

4.3 Explanation of Health, Safety, and Environmental Impact Score

A score of 4 (Major) was given in the Health, Safety, and Environmental impact area as there could likely be life threatening injuries based on the risk scenario if the public, customers, employees or contractors were near a damaged pipeline. A 5 (extensive) did not seem appropriate as it would have to involve many fatalities and/or injuries with many line ruptures occurring within the geological hazard threat area, which would likely be an isolated incident in areas not heavily populated.

4.4 Explanation of Other Impact Scores

Based on the selected reasonable worst case risk scenario, SoCalGas gave the following scores to the remaining impact categories:

- **Operational & Reliability**: As discussed above, the gas infrastructure tends to be more reliable and resilient to climate change. Therefore, the scoring for 2015 was driven more by the electric side of the energy system for this chapter, which scored a 5 (Extensive) because of the potential outages that could likely be over 50,000 potential customers impacted. A lower score would be appropriate for the gas side and a higher score of 6 (Severe) was not appropriate as a pipeline rupture is more likely to occur in an isolated locale rather than across multiple critical locations.[18]
- **Regulatory, Legal, and Compliance**: Climate Change Adaptation was scored a 4 (Major) because any asset damage or failure would likely result from forces of nature beyond the control of SoCalGas; however, such an event may result in regulations for the utility to monitor climate change and the potential impacts to SoCalGas infrastructure and /or update greenhouse gas policy to aid in alleviation of the effects of climate change.[19]
- **Financial**: Climate Change Adaptation was scored a 5 (Extensive) mainly due to the impacts to both electric infrastructure in SDG&E and natural gas infrastructure cost of repairs. See SDG&E Climate Change Adaptation RAMP chapter.

[18] http://www.nbclosangeles.com/news/local/Timeline-The-Northridge-Earthquake-240665071.html

[19] http://www.energy.ca.gov/2008publications/CEC-100-2008-006/CEC-100-2008-006.PDF

4.5 Explanation of Frequency Score

Due to its definition as an emerging risk, in determining the scores for this risk, SMEs have reviewed recent climate projections, including the IPCC Fifth Assessment Report[20] and the U.S. Global Change Research Program's National Climate Assessment,[21] to determine that significant climate change impacts will slowly build over the next 10-30 years. For this reason, the frequency score has been listed as a 3 (Infrequent).

5 Baseline Risk Mitigation Plan[22]

As stated above, Climate Change Adaptation risk involves safety-related threats to gas infrastructure posed by global climate change, and addressing this risk through formal planning and adaptive actions. The 2015 baseline mitigations discussed below includes the current evolution of SoCalGas' management of this risk. They include the amount to comply with laws that were in effect at that time. SoCalGas' mitigation plan for this risk includes the following controls:

- For 2015, SoCalGas' research partnership with the PRCI developed the geological hazard engineering program, including satellite monitoring.
- The geological hazard engineering program included research related to increase extreme weather events and subsidence.
- The efforts to stabilize land movement and/or erosive forces at Storage facilities that were identified in the program.

SMEs from the Gas Engineering and Pipeline Integrity department collaborated to identify and document them. These controls focus on safety-related impacts[23] (i.e., Health, Safety, and Environment) per guidance provided by the Commission in D.16-08-018[24] as well as controls and mitigations that may address reliability.[25] Accordingly, the controls and mitigations described in Sections 5 and 6 address safety-related impacts primarily. Note that the controls and mitigations in the baseline and proposed plans are intended to address various Climate Change Adaptation threats, not just the scenario used for purposes of risk scoring.

[20] *Available at* https://issuu.com/unipcc/docs/syr_ar5_final_full_wcover/1?e=25405816/36622773.
[21] *Available at* http://nca2014.globalchange.gov/report.
[22] As of 2015, which is the base year for purposes of this Report.
[23] The Baseline and Proposed Risk Mitigation Plans may include mandated, compliance-driven mitigations.
[24] D.16-08-018 at p. 146 states "Overall, the utility should show how it will use its expertise and budget to improve its safety record" and the goal of RAMP is to "make California safer by identifying the mitigations that can optimize safety."
[25] Reliability typically has an impact on safety. Accordingly, it is difficult to separate reliability and safety.

6 Proposed Risk Mitigation Plan

The 2015 baseline mitigations outlined in Section 5 will continue to be performed in the proposed plan to, in most cases, maintain the current residual risk level. In addition, SoCalGas is proposing during the 2017-2019 timeframe to expand or add the mitigations addressed below.

1. Gas Infrastructure Resilience and Vulnerability Report

   Gas Engineering will be developing a gas infrastructure resiliency and vulnerability report with the help of external experts to provide guidance to internal operations and engineering design on long-term strategies for climate change adaptation. The report can also be used to support Cities and Counties subject to Senate Bill (SB) 379,[26] which requires updates to their safety elements to address climate adaptation and resiliency. For example, this report will assess what infrastructure is vulnerable to electric outages such as fueling infrastructure for fleets. Examples of questions that are anticipated to be answered in the report could include: What impact to the Companies could occur if they cannot refuel their fleet vehicles in the event of a major electric outage? How could the Companies design a fueling infrastructure to mitigate this impact? How can the Companies design a fleet portfolio that is resilient to electric outages?

2. Geological Hazard Engineering Data Analysis and Flood Hazard Dashboard

   Gas Engineering is developing an enhanced program to automate the assessment of land movement that could cause damages to the system by linking the satellite monitoring and flood hazard data to an enterprise Geographic Information System (eGIS) and create algorithms to identify problem areas with a viewable dashboard or GIS portal. The dashboard will include overlaying data on gas systems for areas that may be vulnerable to flash flooding and landslides to help identify potential problem areas, assets impacted, gas control points and gas service impacts. SoCalGas anticipates that the dashboard can be used to view ground surface changes after weather events to potentially provide early warning of landslides or subsidence. The range of cost for this project is based on historical capital spending for one full-time equivalent (FTE) in the eGIS groups and for the cost of the annual satellite monitoring.

3. Strain Gauge Installation Projects

   Based on the initial monitoring information from 2015, Gas Engineering identified locations where strain gauges[27] need to be installed and maintained by operations for 2016-2019. Gas Engineering will continue identifying locations of the gas infrastructure where strain gauges

[26] Senate Bill 379: http://focus.senate.ca.gov/sites/focus.senate.ca.gov/files/climate/SB_379_Fact_Sheet.pdf.
[27] When pipelines cross landslides, strain gauges are installed on the pipeline to monitor the strain in the longitudinal axis of the pipe. http://www.slopeindicator.com/stories/douglaspass-pipeline.php.

should be installed to monitor vulnerable pipelines that could be exposed to excessive stresses from land movement as new information is assessed from the geological hazard and satellite monitoring programs.

4. Slope Stability & Erosion Control Projects
SoCalGas will continue its efforts in actively working with internal operations groups responsible for the safe operation and maintenance of distribution, transmission and storage pipelines to identify projects and areas where pipelines are prone to slope instability and erosion. SoCalGas intends to identify areas, include them in the eGIS dashboard, analyze adverse effects to assets, and provide appropriate monitoring and/or mitigation for each project identified. Mitigation plans for these types of projects will include, but are not limited to, the following:

   a. Identifying emergency replacement pipe and related equipment
   b. Increase pipeline patrols
   c. Implement satellite monitoring in the areas identified
   d. Install strain gauges in area identified
   e. Complete road and storm drainage improvements
   f. Implement construction storm water management plans
   g. Alter or create channel or drainage paths
   h. Install protective structural walls or retention ponds
   i. Install tie-back systems (soil nails) coupled with shotcrete[28]
   j. Install Riprap, shot rock, or vegetation

7 Summary of Mitigations

Table 4 summarizes the 2015 baseline risk mitigation plan, the risk driver(s) a control addresses, and the 2015 baseline costs for Climate Change Adaptation. While control or mitigation activities may address both risk drivers and consequences, risk drivers link directly to the likelihood that a risk event will occur. Thus, risk drivers are specifically highlighted in the summary tables.

SoCalGas does not account for and track costs by activity, but rather, by cost center and capital budget code. So, the costs shown in Table 4 were estimated using assumptions provided by SMEs and available accounting data.

[28] Structural walls, soil nails, and shotcrete consist of installing passive reinforcements in existing ground to stabilize and support slopes prone to erosion, mudslides and landslides.

http://www.slopeindicator.com/stories/douglaspass-pipeline.php

Table 4: SoCalGas Baseline Risk Mitigation Plan[29]
(Direct 2015 $000)[30]

ID	Control	Risk Drivers Addressed	Capital[31]	O&M	Control Total[32]	GRC Total[33]
1	Land Movement Satellite Monitoring	• Subsidence due to drought/groundwater depletion	n/a	$210	$210	$210
2	Geological Hazard Engineering Analysis	• Increase extreme weather events including, but not limited to wind storms and heavy rainfall	n/a	20	20	20
3	Storage Field Slope Stability & Erosion Projects	• Increase extreme weather events including, but not limited to wind storms and heavy rainfall	470	n/a	470	470
	TOTAL COST		$470	$230	$700	$700

Table 5 summarizes the SoCalGas' proposed mitigation plan (which comprises both baseline and new mitigation activities) and associated projected ranges of estimated O&M expenses for 2019, and projected ranges of estimated capital costs for the years 2017-2019. The scope of the programs and projects in Table 5 extend to the gas infrastructure in SoCalGas and SDG&E territory. It is important to note that SoCalGas is identifying potential ranges of costs in this plan, and are not requesting funding

[29] Recorded costs were rounded to the neared $10,000.
[30] The figures provided in Tables 4 and 5 are direct charges and do not include company loaders, with the exception of vacation and sick. The costs are also in 2015 dollars and have not been escalated to 2016 amounts.
[31] Pursuant to D.14-12-025 and D.16-08-018, the Companies are providing the "baseline" costs associated with the current controls, which include the 2015 capital amounts. The 2015 mitigation capital amounts are for illustrative purposes only. Because projects generally span several years, considering only one year of capital may not represent the entire mitigation.
[32] The Control Total column includes GRC items as well as any applicable non-GRC jurisdictional items. Non-GRC items may include those addressed in separate regulatory filings or under the jurisdiction of the Federal Energy Regulatory Commission (FERC).
[33] The GRC Total column shows costs typically presented in a GRC.

approval. The Companies will request approval of funding, in their next GRC. There are non-CPUC jurisdictional mitigation activities addressed in RAMP; the costs associated with these will not be carried over to the GRC.

Table 5: SoCalGas Proposed Risk Mitigation Plan[34]
(Direct 2015 $000)

ID	Mitigation	Risk Drivers Addressed	2017-2019 Capital[35]	2019 O&M	Mitigation Total[36]	GRC Total[37]
1	Gas Infrastructure Resilience & Vulnerability Report	• Increased frequency and severity of storm events • Sea level rise • Change in precipitation patterns and drought • Change in temperature extremes • Increased wildfire frequency and intensity	n/a	$200 - 400	$200 - 400	$200 - 400
2	Geological Hazard Engineering Data Analysis and Flood Hazard Dashboard	• Increased frequency and severity of storm events • Sea level rise • Change in precipitation patterns and drought	n/a	800 - 2,000	800 - 2,000	800 - 2,000
3	Strain Gauge Installation Projects	• Increased frequency and severity of storm events • Change in precipitation patterns and drought	1,200 - 2,100	50 - 100	1,250 - 2,200	1,250 - 2,200

[34] Ranges of costs were rounded to the neared $10,000.
[35] The capital presented is the sum of the years 2017, 2018, and 2019 or a three-year total. Years 2017, 2018 and 2019 are the forecast years for the Companies' Test Year 2019 GRC Applications.
[36] The Mitigation Total column includes GRC items as well as any applicable non-GRC items.
[37] The GRC Total column shows costs typically represented in a GRC.

4	Slope Stability & Erosion Control Projects	• Increased frequency and severity of storm events • Sea level rise • Change in precipitation patterns and drought • Increased wildfire frequency and intensity	12,600 - 14,400	n/a	12,600 - 14,400	12,600 - 14,400
	TOTAL COST		$13,800 - 16,500	$1,050 - 2,500	$14,850 - 19,000	$14,850 - 19,000

	Status quo is maintained
	Expanded or new activity
*	Includes one or more mandated activities

1. Gas Infrastructure Resilience & Vulnerability Report
   Costs associated with this mitigation are based on quotes from vendors that can provide this type of assessment.

2. Geological Hazard Engineering Data Analysis and Flood Hazard Dashboard
   The range of cost for this project is based on historical capital spending for one full-time equivalent (FTE) in the eGIS groups and for the cost of the annual satellite monitoring.

3. Strain Gauge Installation Projects
   The forecast for this mitigation is based on the costs experienced to date as a proxy.

4. Slope Stability & Erosion Control Projects
   Costs associated with this area are based on the costs experienced to date as a proxy.

8 Risk Spend Efficiency

The risk spend efficiency is a new tool that was developed to attempt to quantify how the proposed mitigations will incrementally reduce risk. A risk spend efficiency analysis was not performed for the Climate Change Adaptation risk because there is no linkage to adaptive or corrective actions which would have any measurable effect on the probability of their predicted safety consequences. Climate drivers are not "events" to be mitigated; however, they can reveal drivers of potential events or vulnerabilities. These climate change-related vulnerabilities identified in other RAMP chapters are discussed in Section 4. Risk spend efficiency calculations have been performed on the other RAMP risks that are vulnerable to the threats brought about by climate change and are analyzed in those risks, rather than in this chapter.

9 Alternatives Analysis

SoCalGas considered alternatives to the proposed mitigations as it developed the incremental mitigation plan for the Climate Change Adaptation risk. Typically, alternatives analysis occurs when implementing activities, and with vendor selection in particular, to obtain the best result or product for the cost. The alternatives analysis for this risk plan also took into account modifications to the proposed plan and constraints, such as budget and resources. The following represents alternatives for the incremental mitigation plan. The viability of each alternative was determined through discussions with stakeholders.

9.1 Alternative 1 – Use Publicly Available Data instead of Satellite Monitoring

SoCalGas considered reducing satellite monitoring efforts in favor of static land movement information provided by publicly available government web sites. This data would not indicate actual land movement, but instead would provide information that the area is prone to a landslide. As a result, the data would not be useful for predicting potential failure of pipelines from land movement and thus not helpful for preventing damage to pipelines.

9.2 Alternative 2 – Reduce Satellite Monitoring with the Installation of Strain Gauges

The second alternative considered was to install strain gauges to reduce satellite monitoring. This alternative is acceptable for monitoring for stresses on the pipeline once the strain gauges are installed, but would not provide information on the surrounding land movement that could impact access issues to the right-of-way.